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1 TITLE OF THE INVENTION

2 VEHICLE SURROUNDINGS MONITORING APPARATUS AND TRAVELING CONTROL
3 SYSTEM INCORPORATING THE APPARATUS

4
5 BACKGROUND OF THE INVENTION

6 1. Field of the invention

7 The present invention relates to a vehicle surroundings
8 monitoring apparatus for recognizing traveling circumstances
9 in front of an own vehicle by stereoscopic cameras, monocular
10 cameras, millimeter wave radars, and the like and for accurately
11 estimating traveling paths of an own vehicle and a traveling
12 control system incorporating such a vehicle surroundings
13 monitoring apparatus.

14 2. Discussion of related arts

15 In recent years, such a traveling control system as
16 detecting traveling circumstances in front of an own vehicle by
17 a camera and the like mounted on a vehicle, estimating traveling
18 paths of the own vehicle from the traveling circumstances data,
19 detecting a preceding vehicle traveling ahead of the own vehicle
20 and making a follow-up control of the preceding vehicle or an
21 intervehicle distance control between the own vehicle and the
22 preceding vehicle, has been put into practical use.

23 For example, Japanese Patent Application Laid-open No.
24 Toku-Kai-Hei 9-91598 discloses a traveling control system in which
25 a traveling path of an own vehicle is estimated from traveling

1 conditions such as yaw rate and other data and a nearest obstacle
2 on the traveling path is detected as a preceding vehicle to be
3 monitored. Further, in the traveling control system, when the
4 preceding vehicle goes out of the traveling path of the own vehicle,
5 the monitoring of the preceding vehicle is released.

6 However, the prior technology in which a traveling path
7 of an own vehicle (hereinafter referred to just as own traveling
8 path) is estimated and a preceding vehicle is caught based on
9 the own traveling path, has a defect that if the estimation of
10 the own traveling path is inaccurate, the capture of the preceding
11 vehicle itself loses reliability and as a result a desired
12 traveling control can not be realized.

13

14 SUMMARY OF THE INVENTION

15 It is an object of the present invention to provide
16 a vehicle surroundings monitoring apparatus capable of stably
17 estimating an own traveling path with high precision and to
18 provide a traveling control system incorporating such a vehicle
19 surroundings monitoring apparatus.

20 According to the present invention, a vehicle
21 surroundings monitoring apparatus inputs images taken by a
22 stereoscopic camera, vehicle speeds, steering wheel rotation
23 angles, yaw rates and ON-OFF signals of a turn signal switch.
24 An own traveling path C is calculated from an own traveling path
25 A obtained from lane markers and side walls and an own traveling

1 path B obtained from yaw rates of the own vehicle. Further, a
2 new own traveling path E is calculated from the own traveling
3 path C and a trace of a preceding vehicle in case where there
4 is no possibility of evacuation of the preceding vehicle and the
5 turn signal switch is turned off and the absolute value of the
6 steering wheel rotation angle is smaller than a specified value
7 and a present own traveling path is calculated from the own
8 traveling path E and the previous own traveling path. In other
9 cases, the present own traveling path is calculated from the own
10 traveling path C and the previous own traveling path.

11

12 BRIEF DESCRIPTION OF THE DRAWINGS

13 Fig. 1 is a schematic diagram showing a traveling
14 control system incorporating a vehicle surroundings monitoring
15 apparatus according to the present invention;

16 Fig. 2 is a flowchart showing a routine for monitoring
17 surroundings of a vehicle;

18 Fig. 3 is a flowchart showing a routine for estimating
19 a traveling path of an own vehicle;

20 Fig. 4 is a flowchart showing a routine for judging
21 the possibility of evacuation of a preceding vehicle using a
22 traveling path C of an own vehicle;

23 Fig. 5a is an explanatory diagram showing a process
24 of producing a new traveling path C of an own vehicle from the
25 traveling path A and the traveling path B;

1 Fig. 5b is an explanatory diagram showing a process
2 of producing the new traveling path C when the traveling path
3 A is erroneously recognized;

4 Fig. 5c is an explanatory diagram showing a process
5 of calculating a new traveling path E from the traveling path
6 C and the traveling path D (traveling path of a preceding vehicle);
7 and

8 Fig. 6 is an explanatory diagram showing a process for
9 establishing a judging counter.

10

11 DESCRIPTION OF THE PREFERRED EMBODIMENT

12 Referring now to Fig. 1, reference numeral 1 denotes
13 a vehicle (own vehicle) on which an intervehicle distance
14 automatically adjusting system (Adaptive Cruise Control: ACC)
15 2 is mounted. The ACC system 2 is constituted by a traveling control
16 unit 3, a stereoscopic camera 4 and a vehicle surroundings
17 monitoring apparatus 5. When the ACC system is set to a constant
18 speed control mode, the vehicle travels at a speed established
19 by a vehicle driver and when the system is set to a follow-up
20 traveling control mode, the vehicle travels at a speed targeted
21 to the speed of a preceding vehicle with a constant intervehicle
22 distance to the preceding vehicle maintained.

23 The stereoscopic camera 4 constituting vehicle forward
24 information detecting means is composed of a pair (left and right)
25 of CCD cameras using a solid-state image component such as Charge

1 Coupled Device and the left and right cameras are transversely
2 mounted on a front ceiling of a passenger compartment at a specified
3 interval of distance, respectively. The respective cameras take
4 picture images of an outside object from different view points
5 and input the picture images to the vehicle surroundings monitoring
6 apparatus 5.

7 Further, the vehicle 1 has a vehicle speed sensor 6
8 for detecting a vehicle speed and the detected vehicle speed is
9 inputted to the traveling control unit 3 and the vehicle
10 surroundings monitoring apparatus 5, respectively. Further, the
11 vehicle 1 has a steering angle sensor 7 for detecting a steering
12 angle and a yaw rate sensor 8 for detecting a yaw rate and the
13 detected steering angle and yaw rate signals are inputted to the
14 vehicle surroundings monitoring apparatus 5. Further, a signal
15 from a turn signal switch 9 is inputted to the vehicle surroundings
16 monitoring apparatus 5. These sensors 6, 7, 8 and the switch 9
17 act as own vehicle traveling conditions detecting means.

18 The vehicle surroundings monitoring apparatus 5 inputs
19 respective signals indicative of picture images from the
20 stereoscopic camera 4, vehicle speeds, steering angle, yaw rate
21 and turn signal and detects frontal information about solid objects,
22 side walls and lane markers in front of the vehicle 1 based on
23 the picture images inputted from the stereoscopic camera 4. Then,
24 the apparatus estimates several traveling paths of the own vehicle
25 1 from the frontal information and traveling conditions of the

1 own vehicle 1 according to the flowchart which will be described
2 hereinafter and estimates a final traveling path of the own vehicle
3 1 from those traveling paths. Further, the apparatus establishes
4 a traveling region A corresponding to a detected solid object
5 based on the final traveling path. Further, the apparatus
6 establishes a traveling region B corresponding to the solid object
7 based on at least either of the traveling region A and the traveling
8 road information and judges whether the solid object is a preceding
9 vehicle, a tentative preceding vehicle or others according to
10 the state of existence of the solid object in the traveling regions
11 A and B. As a result of the judgment, a preceding vehicle in front
12 of the own vehicle 1 is extracted and the result is outputted
13 to the traveling control unit 3. The vehicle surroundings
14 monitoring apparatus 5 includes frontal information detecting
15 means, first own traveling path calculating means, second own
16 traveling path calculating means, third own traveling path
17 calculating means and final own traveling path calculating
18 means.

19 Describing the process of estimating the own traveling
20 path in brief, a new own traveling path C is calculated from the
21 own traveling path A (first own traveling path) obtained based
22 on lane markers and side walls and the own traveling path B (second
23 own traveling path) obtained based on yaw rates of the own vehicle.
24 Then, the possibility of evacuation of the preceding vehicle is
25 judged from the relationship between the own traveling path C,

1 the preceding vehicle and the solid object in the vicinity of
2 the preceding vehicle. In case where there is no possibility of
3 evacuation of the preceding vehicle, the turn signal switch is
4 turned off, and the absolute value of the steering wheel rotation
5 angle is smaller than a specified value, a new own traveling path
6 E is calculated from the own traveling path C and the locus of
7 the preceding vehicle and a present own traveling path is
8 calculated from the own traveling path E and the previous own
9 traveling path. On the other hand, in case where the conditions
10 described above are not satisfied, a present own traveling path
11 is calculated from the own traveling path C and the previous own
12 traveling path. The vehicle surroundings monitoring apparatus
13 comprises forward information detecting means, preceding vehicle
14 recognizing means, own traveling path estimating means, first
15 evacuation possibility judging means and second evacuation
16 possibility judging means.

17 Describing the processing of images from the
18 stereoscopic camera 4 in the vehicle surroundings monitoring
19 apparatus 5, with respect to a pair of stereoscopic images taken
20 by the stereoscopic CCD camera 4, distance information over the
21 entire image is obtained from the deviation amount between
22 corresponding positions according to the principle of
23 triangulation and a distance image representing
24 three-dimensional distance distribution is formed based on the
25 distance information. Then, lane marker data, side wall data such

1 as guardrails, curbs and side walls arranged along the road and
2 solid object data such as vehicles and the like, are extracted
3 by means of the known grouping process and the like by comparing
4 the distance image with the three-dimensional road profile data,
5 side wall data, solid object data and the like stored beforehand.
6 Thus extracted lane marker data, side wall data and solid object
7 data are denoted by different numbers respectively. Further, the
8 solid object data are classified into three kinds of objects,
9 a backward moving object moving toward the own vehicle 1, a still
10 object in standstill and a forward moving object moving in the
11 same direction as the own vehicle 1 based on the relationship
12 between the relative displacement of the distance from the own
13 vehicle and the vehicle speed of the own vehicle 1 and the respective
14 solid object data are outputted.

15 The traveling control unit 3 is equipped with a function
16 of a constant speed traveling control for maintaining the vehicle
17 speed at a value inputted by the vehicle driver and a function
18 of a follow-up traveling control for following up the preceding
19 vehicle in a condition to keep the intervehicle distance between
20 the own vehicle 1 and the preceding vehicle constant. The traveling
21 control unit 3 is connected with a constant speed traveling switch
22 10 constituted by a plurality of switches operated by a constant
23 speed traveling selector lever provided on the side surface of
24 a steering column, the vehicle surroundings monitoring apparatus
25 5, the vehicle speed sensor 6 and the like.

1 The constant speed traveling switch 10 is constituted
2 by a speed setting switch for setting a target vehicle speed at
3 the constant speed traveling mode, a coast switch for changing
4 the target vehicle speed in a descending direction and a resume
5 switch for changing the target vehicle speed in an ascending
6 direction. Further, a main switch (not shown) for turning the
7 traveling control on or off is disposed in the vicinity of the
8 constant speed traveling selector lever.

9 When the driver turns a main switch (not shown) on and
10 sets a desired vehicle speed by operating the constant speed
11 traveling selector lever, a signal indicative of the desired
12 vehicle speed inputs from the constant speed traveling switch
13 10 to the traveling control unit 3 and a throttle valve 12 driven
14 by a throttle actuator 11 makes a feed-back control so as to converge
15 the vehicle speed detected by the vehicle speed sensor 6 to the
16 established vehicle speed. As a result, the own vehicle 1 can
17 travel at a constant speed automatically.

18 Further, when the traveling control unit 3 makes a
19 constant traveling control, supposing a case where the vehicle
20 surroundings monitoring apparatus 5 recognizes a preceding
21 vehicle, which is traveling at a lower speed than the established
22 vehicle speed, the traveling control unit 3 automatically changes
23 over to a follow-up traveling control mode in which the own vehicle
24 travels in a condition retaining at a constant intervehicle
25 distance.

1 When the constant speed traveling control mode is
2 transferred to the follow-up traveling control mode, a target
3 value of an appropriate intervehicle distance between the own
4 vehicle 1 and the preceding vehicle is established based on the
5 intervehicle distance obtained from the vehicle surroundings
6 monitoring apparatus 5, the vehicle speed of the own vehicle 1
7 detected by the vehicle speed sensor 6 and the vehicle speed of
8 the preceding vehicle obtained from the intervehicle distance
9 and the vehicle speed of the own vehicle 1. Further, the traveling
10 control unit 3 outputs a drive signal to the throttle actuator
11 11 and makes a feed-back control of the opening angle of the throttle
12 valve 12 so that the intervehicle distance agrees with the target
13 value and controls the own vehicle 1 in a condition following
14 up the preceding vehicle with the intervehicle distance retained.

15 Next, a vehicle surroundings monitoring program of the
16 vehicle surroundings monitoring apparatus 5 will be described
17 by referring to a flowchart shown in Fig. 2.

18 In this embodiment, the coordinate system of the
19 three-dimensional real space is transferred to a coordinate system
20 fixed to the own vehicle. That is, the coordinate system is composed
21 of X coordinate extending in a widthwise direction of the own
22 vehicle, Y coordinate extending in a vertical direction of the
23 own vehicle, Z coordinate extending in a lengthwise direction
24 of the own vehicle and an origin of the coordinate placed on the
25 road surface directly underneath the central point of two CCD

1 cameras. The positive sides of X, Y and Z coordinates are
2 established in a right direction, in an upward direction and in
3 a forward direction, respectively.

4 The routine shown in Fig. 2 is energized every 50
5 milliseconds. First at a step (hereinafter abbreviated as S) 101,
6 solid object data, side wall data including guardrails, curbs
7 provided along the road and lane marker data are recognized based
8 on images taken by the stereoscopic camera 4. Further, with respect
9 to the solid object data, they are classified into three kinds
10 of objects, backward moving objects, still objects and forward
11 moving objects as described above.

12 Next, the program goes to S102 where the traveling path
13 of the own vehicle is estimated according to a flowchart which
14 will be described hereinafter shown in Fig. 3. First, at S201,
15 the presently obtained own traveling path $Xpr(n)[i]$ is stored
16 as a previous own traveling path $Xpr(n-1)[i]$. [I] denotes node
17 numbers (segment numbers) attached to the own traveling path
18 extending forward from the own vehicle 1. In this embodiment,
19 the own traveling path has 24 segments in a forward direction
20 and is composed of a plurality of straight lines connected with
21 each other. Accordingly, Z coordinate at the segment i is
22 established as follows.

23 Z coordinate at segment i = 10. 24 meters

24 + i · 4.096 meters (I = 0 to 23)

25 Then, the program goes to S202 where an own traveling

1 A ($X_{pra}[i]$, $i = 0$ to 23) is calculated according to the following
2 method A or B.

3 **Method A: Estimation of traveling path based on lane markers**

4 In case where both or either of left and right lane
5 markers data are obtained and the profile of the lane on which
6 the own vehicle 1 travels can be estimated from these lane markers
7 data, the traveling path of the own vehicle is formed in parallel
8 with the lane markers in consideration of the width of the own
9 vehicle 1 and the position of the own vehicle 1 in the present
10 lane.

11 **Method B: Estimation of traveling path based on side wall data**

12 In case where both or either of left and right side
13 walls data are obtained and the profile of the lane on which the
14 own vehicle 1 travels can be estimated from these side walls data,
15 the traveling path of the own vehicle is formed in parallel with
16 the side walls in consideration of the width of the own vehicle
17 1 and the position of the own vehicle 1 in the present lane.

18 In case where the own traveling path A can not be
19 established according to any of the methods A, B mentioned above,
20 it is calculated according to the following methods C or D.

21 **Method C: Estimation of traveling path based on a trace of the**
22 **preceding vehicle**

23 The own traveling path is estimated based on the past
24 traveling trace extracted from the solid object data of the
25 preceding vehicle.

1 **Method D: Estimation of path based on trace of the own vehicle**

2 The own traveling path is estimated based on the
3 traveling conditions such as yaw rate γ , vehicle speed V and
4 steering wheel rotation angle θ_H of the own vehicle 1.

5 After that, the program goes to S203 in which an own
6 traveling path B ($X_{prb}[I]$, $I = 0$ to 23) is calculated based on
7 the yaw rate γ according to the following processes.

8
$$X_{prb}[i] = \gamma \cdot Z^2 + 10240 \text{ (millimeters)}$$

9
$$Z = 4096 \cdot i + 10240 \text{ (millimeters)}$$

10 Thus obtained own traveling path B ($X_{prb}[i]$) is
11 corrected as follows by the state of the steering wheel rotation
12 angle θ_H , that is, by respective states, during traveling
13 straightforwardly, during turning a curve and during returning
14 the steering wheel to straight.

15
$$X_{prb}[i] = X_{prb}[i] \cdot \alpha$$

16 where α is a correction coefficient.

17 The correction coefficient α is established to a value
18 (0) from 0 to 1.0. When the vehicle travels straight or when
19 the vehicle transfers from curve to straight, the correction
20 coefficient α is established to a small value so as to reduce
21 the curvature of the traveling path. When the vehicle turns a
22 curve, the correction coefficient α is established to 1.0 so as
23 to employ the curvature derived from the yaw rate γ as it is.

24 Then, the program goes to S204 where an own traveling
25 path C ($X_{prc}[i]$, $i = 0$ to 23) is calculated based on the own traveling

1 path A (Xpra[i], i = 0 to 23) and the own traveling path B (Xprb[i],
2 i = 0 to 23) as shown in Fig. 5a.

3
$$Xprc[i] = (Xpra[i] \cdot \lambda + Xprb[i] \cdot \mu / (\lambda + \mu))$$

4 where λ and μ are values varying according to the result of
5 recognition of circumstances such as road widths.

6 Thus, in case where the accuracy of the own traveling
7 path A (Xpra[i], i = 0 to 23) is exacerbated by erroneous recognition
8 of lane markers or side walls as shown in Fig. 5b, for example,
9 the recognition accuracy of the own traveling path can be prevented
10 from going down by primarily using the own traveling path B
11 (Xprb[i], i = 0 to 23) by means of establishing μ to a larger
12 value than λ .

13 Then, the program goes to S205 in which it is judged
14 whether or not a preceding vehicle is detected and if detected,
15 the program goes to S206 where the segment kpo on Z coordinate
16 of the preceding vehicle is established as follows:

17
$$Kpo = (Z \text{ coordinate of preceding vehicle} - 10.24) / 4.096$$

18 Then, the program goes to S207 in which the possibility
19 of evacuation of the preceding vehicle is judged using the own
20 traveling path C (Xprc[i], i = 0 to 23) calculated at S204,
21 according to a flowchart shown in Fig. 4.

22 In this routine, first, at S301, it is judged whether
23 or not a preceding vehicle exists. If there is no preceding, the
24 program goes to S302 wherein a judging counter TIME is cleared
25 (TIME = 0) and then goes to S303 wherein it is judged that there

1 is no preceding vehicle and such a signal is outputted, leaving
2 the routine. In this embodiment, the signal is the same as a signal
3 indicating that there is a possibility of evacuation of the
4 preceding vehicle. Further, the aforesaid judging counter TIME
5 is for expressing the possibility of evacuation of the preceding
6 vehicle numerically.

7 On the other hand, in case where it is judged at S301
8 that there is a preceding vehicle, the program goes to S304 where
9 the absolute value CAL of the difference between X coordinate
10 kpx of the preceding vehicle and X coordinate of the own traveling
11 path C (Xprc[i], i = 0 to 23) on Z coordinate of the preceding
12 vehicle, is calculated ($CAL = |kpx - xpx|$).

13 The processes from S305 to S311 will be described by
14 reference to Fig. 6.

15 First, at S305, it is judged whether or not the segment
16 kpo of Z coordinate of the preceding vehicle is larger than 17.
17 that is, the division is more than 80 meters ahead. If kpo is
18 larger than 17, the program goes to S306 in which the judging
19 counter TIME is cleared ($TIME = 0$) and then goes to S307 a signal
20 indicative of no possibility of evacuation of the preceding vehicle
21 is outputted, leaving the routine.

22 Further, in case where it is judged at S305 that the
23 segment kpo of Z coordinate of the preceding vehicle is smaller
24 than 80 meters, the program goes to S308 in which the judgment
25 counter TIME is initialized according to the position of the

1 preceding vehicle as follows (first evacuation possibility judging
2 means):

3 A. In case where CAL is smaller than 500 millimeters, that is,
4 the preceding vehicle is in the vicinity of the traveling path
5 of the own vehicle (region 1 of Fig. 6),

6 $TIME = 0$

7 B. In case where CAL is larger than 500 millimeters, that is,
8 the preceding vehicle is regarded as traveling apart from the
9 traveling path of the own vehicle

10 (1) In case where the segment kpo of Z coordinate of the
11 preceding vehicle is smaller than 80 meters and larger than 50
12 meters:

13 In case of $2000 \leq CAL \leq 3000$ millimeters (region II of
14 Fig, 6)

15 $TIME = TIME + 5$

16 In case of other than above (particularly, outside of
17 the region II, note that the preceding vehicle travels
18 around curves)

19 $TIME = TIME - 5$

20 (2) In case where the segment kpo of Z coordinate of the
21 preceding vehicle is smaller than 50 meters and larger than 30
22 meters:

23 In case of $1500 \leq CAL \leq 2500$ millimeters (region III of
24 Fig. 6)

25 $TIME = TIME + 10$

1 In case of other than above (particularly, outside of
2 the region III, note that the preceding vehicle travels
3 around curves)
4 TIME = TIME - 10
5 (3) In case where the division of kpo of Z coordinate of
6 the preceding vehicle is smaller than 30 meters:
7 In case of $CAL \geq 1000$ millimeters (region IV of Fig. 6)
8 TIME = TIME + 30
9 In case other than above
10 TIME = TIME - 10
11 Then, the program goes to S309 wherein the judging
12 counter TIME is established by the solid object other than the
13 preceding vehicle (second evacuation possibility judging means).
14 For example, in case where a forward traveling solid object enters
15 a traveling region kpo ± 1 , the judging counter TIME initialized
16 by S308 is additionally initialized as follows:
17 TIME = TIME + 10
18 Then, the program goes to S310 in which it is judged
19 whether or not TIME is larger than a threshold value (for example
20 100). If TIME is smaller than 100, the program goes to S307 where
21 after a signal indicative of no possibility of evacuation of the
22 preceding vehicle is outputted, the program leaves the routine.
23 If TIME is larger than 100, the program goes to S311 where a signal
24 indicative of the possibility of evacuation of the preceding
25 vehicle is outputted and leaves the routine. Thus, since the

1 judgment of evacuation of the preceding vehicle is made by the
2 own traveling path C ($X_{prc}[i]$, $i = 0$ to 23) and the position where
3 the preceding vehicle exists, even when no lane markers are seen,
4 an accurate judgment of evacuation of the preceding vehicle is
5 available. Further, the accurate judgment of evacuation of the
6 preceding vehicle can prevent the ACC system from following up
7 the preceding vehicle hazardously.

8 Since the introduction of this evacuation judgment
9 process enables an accurate judgment of the possibility of
10 evacuation of the preceding vehicle as a monitoring object based
11 on information of the position of the preceding vehicle, the
12 traveling path of the own vehicle and the objects in the
13 neighborhood of the preceding vehicle, not only the preceding
14 vehicle can be continued to be caught as a monitoring object,
15 but also every behavior of the preceding vehicle including the
16 change of the preceding vehicle from one to another can be detected
17 with quick responsibility and accuracy. As a result, the traveling
18 control can be executed stably in a manner similar to driver's
19 driving senses.

20 Thus, after the judging processes of the possibility
21 of evacuation of the preceding vehicle are executed using the
22 own traveling path C ($X_{prc}[i]$, $i = 0$ to 23) at S207, the program
23 goes to S208 where it is judged from the result of the judgment
24 at S207 whether or not there is a possibility of evacuation of
25 the preceding vehicle.

1 If it is judged that there is no possibility of
2 evacuation of the preceding vehicle, the program goes to S209
3 wherein it is judged whether or not the turn signal switch 9 of
4 the own vehicle is turned on. If the turn signal switch 9 is turned
5 off, the program goes to S210 in which it is judged whether or
6 not the absolute value of the steering wheel rotation angle is
7 larger than a specified value, for example 90 degrees. If it is
8 smaller than the specified value, the program goes to S211 where
9 a new own traveling path E ($Xpre[i]$, $i = 0$ to 23) is based on
10 the own traveling path C ($Xprc[i]$, $i = 0$ to 23) and the own traveling
11 path D ($Xpre[i]$, $i = 0$ to 23) according to the following formula:

12
$$Xpre[i] = Xprc[i]$$

13 where $i = 0$ to $(kpo - 2)$, $(kpo + 1)$ to 23

14
$$Xpre[i] = (Xprc[i] + xpo \cdot \kappa) / (1.0 + \kappa)$$

15 where $i = kpo - 1, kpo$

16 In this embodiment, the own traveling path D is expressed only
17 by X coordinate xpo at the division kpo of Z coordinate of the
18 preceding vehicle. Further, κ is a variable varying according
19 to the recognition of circumstances. When the recognition of
20 circumstances is inferior, κ is established to a large value.
21 That is, in the process of S211, as shown in Fig. 5c, taking the
22 case where the preceding vehicle changes the lane into
23 consideration, only the neighborhood of the preceding vehicle
24 is corrected with respect to the preceding vehicle so that the
25 ACC system 2 operates with accuracy.

1 Then, the program goes to S212 wherein the present own
2 path (Xprc[i], i = 0 to 23) is calculated from the own traveling
3 path E (Xpre[i], i = 0 to 23) newly calculated presently and the
4 own traveling path (Xpr(n-1)[i], i = 0 to 23) calculated in the
5 previous cycle and stored at S201 as follows:

$$6 \quad Xpr(n)[i] = Xpr(n-1)[i] \cdot \psi - Xpre[i] \cdot (1.0 - \psi)$$

7 where ψ is a value established according to traveling
8 conditions of the own vehicle. For example, when the vehicle
9 transfers from curved road to straight road, ψ is established
10 to a small value so as to impose more weight on the own traveling
11 path E (Xpre[i], i = 0 to 23) calculated newly, presently and
12 otherwise ψ is established to a large value so as to impose more
13 weight on the own traveling path (Xpr(n-1)[i], i = 0 to 23)
14 calculated in the previous cycle. As a result, the response in
15 accordance with the traveling conditions can be obtained.

16 On the other hand, in case where it is judged at S205
17 that there is no preceding vehicle, or in case where it is judged
18 at S208 that there is a possibility of evacuation, the program
19 goes to S213. Similarly, in case where it is judged at S209 that
20 the turn signal switch 9 is turned on, or in case where it is
21 judged at S210 that the absolute value of the steering wheel rotation
22 angle is larger than a specified value, the program goes to S213.

23 At S213, the present own traveling path (Xpr(n)[i],
24 i = 0 to 23) is calculated from the own traveling path C (Xprc[i],
25 i = 0 to 23) calculated at S204 and the previous own traveling

1 path (Xpr(n-1)[i], i = 0 to 23) stored at S201 in the following
2 manner:

$$3 \quad Xpr(n)[i] = Xpr(n-1)[i] \cdot \psi - Xprc[i] \cdot (1.0 - \psi)$$

4 After the own traveling path is estimated, the program
5 goes to S103 where the preceding vehicle is extracted, leaving
6 the routine. The extraction of the preceding vehicle is performed
7 as follows:

8 First, the traveling region A is established based on
9 the traveling path of the own vehicle according to the solid object.
10 Further, the traveling region B is established based on at least
11 either of the traveling region A and road information (road profile
12 estimated from lane markers and side walls). Then, if the detected
13 solid object exists in the traveling region A and if the duration
14 for which the solid object stays in either of the traveling regions
15 A and B, is larger than a specified time and if the solid object
16 is a forward moving object and if the object is nearest one to
17 the own traveling vehicle 1, the solid object is regarded and
18 extracted as a preceding vehicle.

19 According to the embodiment of the present invention,
20 since the final own traveling path is calculated based upon the
21 own traveling path A (Xpra[i], i = 0 to 23) obtained from lane
22 marker and side wall data and the own traveling path B (Xprb[i],
23 i = 0 to 23) derived from the yaw rate of the own vehicle 1 and
24 the own traveling path D (Xprd[i], i = 0 to 23) calculated based
25 on the trace of the preceding vehicle, the own traveling path

1 can be estimated accurately, stably and securely.

2 Further, when the own traveling path C ($X_{prc}[i]$, $i =$
3 0 to 23) is calculated from the own traveling path A ($X_{pra}[i]$,
4 $i = 0$ to 23) and the own traveling path B ($X_{prb}[i]$, $i = 0$ to 23)
5 and the own traveling path E ($X_{pre}[i]$, $i = 0$ to 23) is newly
6 calculated using the own traveling path C ($X_{prc}[i]$, $i = 0$ to 23)
7 and the own traveling path D ($X_{prd}[i]$, $i = 0$ to 23) produced based
8 on the traveling trace of the preceding vehicle, since an accurate
9 judgment process of evacuation is executed using the own traveling
10 path C ($X_{prc}[i]$, $i = 0$ to 23) and the own traveling path E ($X_{pre}[i]$,
11 $i = 0$ to 23) is synthesized according to the result of the judgment,
12 unnecessary calculations according to every behavior of the
13 preceding vehicle can be effectively prevented from being made
14 and as a result an accurate calculation of the own traveling path
15 can be performed.

16 Further, the ON-OFF signal of the turn signal switch
17 9 and the value of the steering wheel rotation angle enable to
18 obtain the final own traveling path in a natural manner reflecting
19 driver's intention.

20 Furthermore, when the own traveling path E ($X_{pre}[i]$,
21 $i = 0$ to 23) is calculated using the own traveling path C ($X_{prc}[i]$,
22 $i = 0$ to 23) and the own traveling path D ($X_{prd}[i]$, $i = 0$ to 23)
23 derived from the traveling trace of the preceding vehicle, since
24 the possibility of evacuation is judged not only according to
25 the behavior of the preceding vehicle but also according to that

1 of the solid object other than the preceding vehicle in the
2 neighborhood of the preceding vehicle, the judgment of evacuation
3 can be made more correctly.

4 The entire contents of Japanese Patent Application No.
5 Tokugan 2002-271905 filed September 18, 2002, is incorporated
6 herein by reference.

7 While the present invention has been disclosed in terms
8 of the preferred embodiment in order to facilitate better
9 understanding of the invention, it should be appreciated that
10 the invention can be embodied in various ways without departing
11 from the principle of the invention. Therefore, the invention
12 should be understood to include all possible embodiments which
13 can be embodied without departing from the principle of the
14 invention set out in the appended claims.

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